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Moving Onwards:

An Action Continuation Strategy in Finding the Way

Wijnand A. P. van Tilburg

University of Southampton; University of Limerick

Eric R. Igou

University of Limerick

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Authors Note

Wijnand A. P. van Tilburg, Department of Psychology, University of Limerick, Republic of Ireland; Eric R. Igou, Department of Psychology, University of Limerick, Republic of Ireland.

Wijnand A. P. van Tilburg is now at the Centre for Research on Self and Identity, School of Psychology, University of Southampton, Southampton, United Kingdom.

This research was in part funded by the Irish Research Council for the Social Sciences and Humanities (IRCHSS). We wish to thank Megan Lally and the Students of the 2012 Decision Making module for their help in collecting data. Correspondence concerning this article should be addressed to Wijnand A. P. van Tilburg, Centre for Research on Self and Identity, School of Psychology, University of Southampton, University Road, Southampton, SO17 1BJ, United Kingdom; W.A.Van-Tilburg@soton.ac.uk

Abstract

In four studies we examined people's strategies when deciding between multiple routes of equivalent length in way-finding tasks. The results reveal the important role of continuing behavior when faced with a choice from multiple viable routes. After affirming the existence of asymmetric preferences for alternatives (Study 1 & 2), we observed that variations of simple known-environment mazes supported action continuation as prevailing process over alternative strategies such as preference for long initial path segments, paths with a least deviating angle, and a modified hill climbing strategy (Study 3). Moreover, asymmetric preferences disappeared with the absence of initial behavior to inform subsequent decision making (Study 4). Results are discussed within the context of decision making, navigation strategies, and everyday life path finding.

Keywords: Way-Finding; Asymmetric Preferences; Movement; Spatial Cognition; Navigation

Moving Onwards:

An Action Continuation Strategy in Finding the Way

Life is replete with choices, ranging from major decisions, such as buying a house, to more mundane decisions, such as choosing to wear comfortable versus pretty shoes. Given the abundance of choice options in life, it comes as no surprise that a vast amount of psychological research addresses people's judgment, decision making, and problem solving (e.g., Baron, 2008; Koehler & Harvey, 2004; Robertson, 2001). Numerous studies have sought to unravel the processes involved in choosing between options that differ on one or more relevant dimensions (e.g., Triantaphyllou & Mann, 1989); others have explored preferences for alternatives with similar expected outcomes (e.g., Tversky & Kahneman, 1981). Overall, it is evident that decision making is a complex and dynamic process that involves many psychological processes, both conscious and unconscious ones (e.g., Dijksterhuis & Nordgren, 2006).

After observing in navigation tasks asymmetric preferences for routes of similar lengths directed at a common goal (Christenfeld, 1995), numerous scholars have examined the processes underlying preferences in such way-finding tasks (e.g., Bailenson, Shum, & Uttal, 1998; Bailenson, Shum, & Uttal, 2000; Hochmair & Frank, 2002; Hochmair & Karlsson, 2004). Our research further explores people's preferences and the underlying process. We argue that if people have a choice between two paths that seem similar, with one that involves an early change of movement and another that involves continued movement, they prefer the latter, a strategy that we call *action continuation*. In our studies, we compared this strategy to several alternative strategies, most noteworthy to an *initial segment strategy* (Bailenson et al., 2000), a *least angle strategy* (Hochmair & Frank, 2002), and a modification of the *hill climbing strategy* (e.g., Robertson, 2001). In the following sections, we will first

give an overview of the literature on preferences for one of equivalent routes in navigation tasks before we will introduce our approach in more detail.

Equivalent Options in Navigation Tasks

People have long been intrigued by navigation tasks with equally valuable outcomes of choice alternatives. For example, the famous “Buridan’s ass” paradox, dating back to Aristotle, describes the problem of an ass (i.e. donkey) located in the middle of two equally attractive stacks of hay (although some versions replace one stack of hay with water; see Zupko, 2011). The paradox propagates that the donkey will ultimately starve as it cannot develop a preference for either one of the stacks. In this example, the hay options represent ways to achieve the goal of eating. In the navigation task we are addressing here there is one goal to get to, via equally long routes. Christenfeld (1995) examined people’s behavior when faced with several routes of identical length. Bailenson and colleagues (1998; 2000) examined whether the length of an initial segment within a navigation route systematically impacts on preferences, whereas Hochmair and Frank (2002) studied the influence of segments requiring a turn of different angles en route to a target.

What can people do when being faced with a navigation problem that offers such equivalent options (for examples, see Table 1)? One rather unlikely possibility is that people refrain from making a decision and simply don’t move, similar to Buridan’s donkey. A second possibility would be random patterns of preference. A third possibility would be that people systematically prefer one alternative over another. Indeed, literature consistently supports the last alternative: preferences for routes of equivalent length leading to the same outcome are asymmetric. For example, the pioneering work of Christenfeld (1995) evidences that when faced with multiple viable routes of equal length, people choose those that involve a turn farthest away from one’s starting position; people seem to postpone turns.

Decision Strategies in Navigation Decisions with Equivalent Options

Why do these asymmetric effects on route preferences emerge? Christenfeld (1995) speculated that postponing a turn might result from people's attempts to minimize mental efforts in decision making. General support for this proposition was obtained by subsequent studies that documented the impact of heuristics in such navigation tasks. Two important accounts are briefly highlighted in the following sections, followed by the alternative modified "hill climbing" strategy, and the action continuation strategy that we propose.

Initial Segment Strategy

Extending Christenfeld's (1995) research, Bailenson and colleagues (2000) tested whether asymmetric preferences in navigation tasks with routes of equal length functioned as an effort minimizing heuristic and whether the length of route segments was a determining factor underlying the phenomenon observed in these prior studies. In a series of experiments, Bailenson and colleagues presented people with decision tasks in which they considered routes on a map and were requested to select either one of two paths to a target, each consisting of segments and turns. Importantly, the authors manipulated the order of the segments such that one of the alternatives *started* with a relatively long straight part of the route whereas the other *ended* with the relatively long straight segment; the paths nonetheless yielded equal length. In several alterations of this basic set-up—including variation in the amount of turns and altering the general navigation direction—these researchers found that people indeed prefer those routes that yield the lengthiest initial segment (i.e. that allowed them to postpone turning as long as possible). Moreover, shortening the amount of time that people had to process the decision making tasks *increased* their asymmetric preferences, strongly suggesting that the process underlying the choices indeed resembles a simple decision making rule or heuristic.

Least Angle Strategy

Besides the initial segment strategy investigated by Bailenson (2000), Hochmair and Frank (2002) proposed another heuristic that might explain the asymmetric preferences documented by Christenfeld (1995). Specifically, they introduced a strategy that resembled features of a compass routing algorithm (Bose & Morin, 1999): the *least angle strategy*. These researchers reasoned that when choosing what turn to take, people tend to prefer the turn that allows them to travel with the least deviating angle from their orientation towards the goal. Thus, when faced with the decision of whether or not to take a turn, people will choose the route that most closely resembles a straight path towards their destination. Indeed, several studies conducted by Hochmair and Karlsson (2004) indicate that people have a preference for those routes that show the least angle of deviation in relation to the target. This strategy has so far been studied in *unknown* environments, that is, settings in which people are unaware of the exact layout of the map, yet there is no reason to assume that this strategy is exclusive to such unknown environment contexts only. Indeed, Hochmair and Frank (2002) offer the least angle strategy as a potential explanation for Christenfeld's (1995) finding on behavior in known environments.

The least angle strategy and the initial segment predict similar choices when people are faced with navigation tasks in which the first segment is both the longest and yields the least deviating angle, such as in the tasks used by Christenfeld (1995; for another example, see Table 1; *a*). However, they make notably different predictions in other contexts, specifically when the path yielding the longest initial segment angles away from the straight line to the goal to a greater extent than the short initial segment alternative. In examining situations like these, Hochmair and Karlsson (2004) found support for dominance of the least angle strategy over the initial segment strategy in predicting navigation behaviors, at least within an unknown environment context.

Immediate Proximity

Besides the strategies outlined above, people may prefer paths that seem to take them immediately in closest proximity of their target. In navigation tasks where the required horizontal difference between the starting position and the target location is greater than the vertical difference with the destination, traveling a distance horizontally takes people in closer direct proximity compared to when the same distance is travelled vertically, as propagated by the Pythagorean Theorem. Thus, people may simply choose a route that takes them as proximal to the target as quickly as possible, although the total required traveling distance for both alternatives is equal.

The possibility that people may seek to reduce their immediate proximity in way-finding behavior can be interpreted as a specific case of a *hill climbing strategy*, in which people attempt to solve problems by forming and pursuing more easily obtained subgoals. As an example, one can think of the subgoals to first dominate the center on the board when playing chess and then seeking to capture the component's Queen prior to attempting check-mate. Although hill climbing can be problematic when solving a problem requires behavior that at some point increases the distance to the end-goal, such as in the Tower of Hanoi or Missionaries and Cannibals problems, this strategy is nonetheless used by people in many problem solving tasks (e.g., Newell & Simon, 1972; Robertson, 2001; Simon & Reed, 1976; Thomas, 1974). One possibility is thus that systematic preferences observed in the navigation problems studied by Christenfeld reflect the default use of a modified hill climbing strategy commonly observed in solving more complex problems.

Action Continuation Strategy

Although the above strategies provide plausible explanations for the asymmetric preferences observed in Christenfeld's (1995) research on navigation behavior in known environments, we propose an alternative, more succinct, explanation: people prefer to

continue their course of action if alternative courses do not seem beneficial or necessary.

Thus, even though the observations by Christenfield are *consistent* with the other strategies, we pose that the *action continuation strategy* best explains people's preferences when navigating in such environments.

Specifically, the proposed action continuation strategy shares features with other prominent theories in problem solving and self-regulation. The classic "test-operate-test-exit" (TOTE) model in problem solving (Miller, Galanter, & Pribram, 1960) and theories of self-regulation (e.g., Carver & Scheier, 1998) hold that attempts to *amend* behavior is critically dependent on monitoring and feedback processes during goal pursuit. People adjust behavior based on what the "test" data suggests, that is, people monitor whether current behavior is an effective means for achieving the target goal (e.g., Vroom, 1964). More specifically, progress monitoring theory (MacGregor, Ormerod, & Chronicle, 2001) poses that for solving rather complex problems a person is most likely to abandon an ineffective strategy when the relative effort or time spent using the selected strategy is perceived to outweigh the actual progress made, reflecting a phenomenon referred to as *criterion-failure*. In a study, Ormerod, MacGregor, and Chronicle (2002) examined people's ability to solve different versions of the 8-coin problem, in which a set of coins needs to be rearranged to make each coin touch exactly 3 others; the counter-intuitive solution is to place coins on *top* of others. Importantly, people were more likely to find the correct solution to this problem when the coins were arranged in such that the problem yielded no valid first moves in two dimensions. As a result of immediately failing to find moves in two-dimensions, participants were more likely to consider the (successful) use of three dimensions. These findings suggest that problem solving can benefit from the presence of negative feedback regarding ineffective strategies. Although the decision making processes such as in the 8-coin problem are arguably more complex than way-finding in known environments, this observation nonetheless suggests that

in the *absence* of cues that suggest the need for a change in strategy, people are inclined to continue their current course of action.

Moreover, an action continuation strategy is consistent with the notion that people utilize strategies in movement behavior that minimize cost functions (e.g., inaccuracy, energy, time etc.; Trommershäuser, Maloney, & Landy, 2009) where changing behavior may be considered costly. Indeed, switching between tasks is considered to be expensive (e.g., Rogers & Monsell, 1995), and underlies psychological phenomena such as performance on the implicit association test (e.g., Klauer & Mierke, 2005). In line with the action continuation principle, changing the engagement from one particular task to another requires effortful suppression of the original task, a phenomenon called task-set inertia (Allport, Styles, & Hsieh, 1994). Moreover, decision making research attests people's tendency to rely on the status quo or prior attained anchors when making decisions (e.g., Jacowitz & Kahneman, 1995; Samuelson & Zeckhauser, 1988).

Importantly, the action continuation strategy is a straightforward process in way-finding behaviors in known environments. That is, besides being broadly consistent with research in other domains of decision making, this strategy offers a highly parsimonious explanation of way-finding. Moreover, this strategy allows for testable predictions and comparisons to alternative strategies that seem to explain way-finding.

To illustrate how this account differs from the previous in its predictions, consider the following navigation setting: One approaches from a horizontal path and can choose from two routes towards a goal that is located at a greater vertical distance than horizontal distance in Euclidean space. A first alternative route requires an early turn immediately into long vertical path (hence long initial segment), whereas a second route starts with the relatively short horizontal segment (see Table 1; *b* for an illustration). According to the initial segment approach, people will opt for the first turn, ending up in the first long vertical segment. The

least angle strategy would predict a similar preference given that the first vertical path yields a smaller deviating angle from a straight line towards the goal relative to the upper horizontal segment. Also the immediate proximity strategy would predict taking the first turn as movement in this direction is associated with a smaller immediate direct distance from the goal compared to the alternative. The action continuation strategy, however, would predict otherwise: the upper horizontal segment allows for the continuation of behavior (the original horizontal navigation direction), leading to preferences for the upper path, regardless of its relatively short length and large deviating angle.

The Current Research

In a series of four studies, we systematically examined whether people use an action continuation strategy as part of way-finding in known environments. In Study 1 and 2, we first sought to establish the phenomenon of asymmetric preferences as identified by Christenfeld (1995). This was done by embedding a choice between two equally lengthy routes within a maze through which people were required to trace a path and by asking people to walk through a large chalk-drawn maze. In Study 3, we presented people with different versions of the original maze that allowed us to contrast predictions based on the action continuation strategy against the initial segment, the least angle, and immediate proximity strategy. After finding overall support for the action continuation strategy, we tested whether asymmetric preferences disappeared when we took away the presence of navigation behavior prior to path choices in Study 4. Table 1 summarizes the predictions of each of the alternative accounts across the studies.

Study 1: An Embedded Multiple-Route Maze

Study 1 was designed as a first test of whether people display asymmetric preferences in a navigation task with two distinct but functionally equivalent solutions. Inspired by earlier work of Christenfeld (1995), we investigated this navigation problem in the context of a maze

puzzle. Participants were presented with a printed maze in which they had to find the route from the entrance to the exit and the maze embedded a choice between two routes that both led to a viable solution after the same distance traveled (see Figure 1). We predicted that people would navigate through the maze by opting for the route involving the latest turn: we expected that the odds for choosing the “upper path” over the “lower path” would be higher when navigating from west to east, relative to when navigating from east to west.

Method

Fifty-one students ($M_{\text{age}} = 20.98$, $SD = 4.31$; 31 women, 19 men, 1 undisclosed) on the University of Limerick campus agreed to voluntarily participate in this paper-and-pencil study. After giving informed consent, participants traced a line through a maze from a location labeled “start” to “finish.” Importantly, participants were randomly assigned to a version of the maze in which they went from west to east, or from east to west; the location of the labels “start” and “finish” were varied accordingly. After tracing the line, participants reported demographic information before they were debriefed and thanked for their participation.

Results and Discussion

A Chi-Square test indicated that choices for either the upper path versus the lower path were conditional on the direction through the maze, $\chi^2(1) = 10.85$, $p < .001$, $\phi = 0.46$ (Figure 2). Specifically, whereas 60% of participants choose the upper path when going from west to east, only 15% choose to do so when traversing from east to west. Thus, the probabilities of selecting the upper or lower routes are not identical across directions, even though the instrumentality of the paths are functionally equivalent regardless of whether going from west to east or from east to west. These results are consistent with the patterns observed by Christenfeld (1995).

Study 2: Behavioral Replication

The previous study confirmed the prediction that people prefer to continue their course of action before changing it in rather than the reverse in the domain of way-finding and they were consistent with the results first documented by Christenfeld (1995). Ultimately, the results obtained from this research should translate to actual navigations rather than drawing lines through mazes. Hence, prior to capitalizing on testing the action continuation strategy against alternative accounts, we sought to extend the basic pattern of results into a behavioral context. To this end, we asked people to walk through a known-environment chalk-drawn maze consisting of the identical options element that was embedded in the larger maze of Study 1. The part of the maze that involved a decision between the two paths is henceforward referred to as the “default maze” (Table 1; *a*).

Method

Thirty-five passing people ($M_{\text{age}} = 22.56$; $SD = 6.51$; 18 women, 17 men) on the main campus square were asked if they wanted to partake in the current study. After giving informed consent, participants were led to an entrance of a chalk maze, which was approximately 5m by 1.5m, with paths approximately 50cm wide. The horizontal and vertical segments from the turn point measured approximately 1m and 2.5m (measured from the middle of the path), and participants could see the entire layout of the maze. Participants were randomly led to either the west or the east side of the maze and were asked to walk to the exit on the other side without crossing the chalk lines. Participants’ choices were recorded and they provided demographic information afterwards. Upon completion of the study, participants were debriefed and thanked.

Results and Discussion

A Chi-Square test indicated that choices for either the upper path versus the lower path were conditional on the direction through the maze, $\chi^2(1) = 4.27$, $p = .04$, $\phi = 0.35$ (Figure 2).

Specifically, whereas 53% of the participants choose the upper path when going from west to east, only 19% did so when going from east to west. These behavioral results essentially replicated those of Study 1, demonstrating them across different types of actions, namely drawing lines through a maze and walking through a maze. We proceeded in Study 3 by plotting the action continuation strategy against alternative accounts.

Study 3: Contrasting Accounts

The results of Study 1 and 2 suggest that participants' relative preferences for the upper over the lower route were higher when the former option allowed them to maintain their course of action and vice versa. Although this pattern is consistent with the proposed action continuation strategy, it is also consistent with alternative accounts. First of all, people may use a hill climbing strategy in which they try to immediately get as proximal as possible to the desired location. Although both routes are identical in *total* length, people are at a greater distance from the exit "as the crow flies" after traversing the first turn compared to when travelling the same distance through the path that does not require taking the first turn. Second, besides allowing the continuation of the ongoing course of action, the preferred paths also yielded the longest initial segments (Bailenson et al., 1998; 2000). Third, the deviating angle of the preferred paths was smaller than those of their alternatives, which is consistent with the least angle strategy (Hochmair & Frank, 2002). Besides these established strategies, one might even argue that people might simply have decided to "stay on the left", similar to navigation in traffic within the country of study. In the current study we presented people with variations of the default maze to contrast predictions of each of these accounts against each other.

Method

Ninety-four students ($M_{\text{age}} = 20.49$; $SD = 3.30$; 60 women, 34 men) on campus agreed to partake in this paper-and-pencil study. After giving informed consent, participants traced a

line through four non-embedded maze-puzzles. We tested the action continuation strategy and the abovementioned alternative accounts by using modified versions of the task from Study 2. The default maze yielded initial segments of 2.5cm and 0.7cm (measured from the middle of the path starting at the turn location), with deviation angles of 10.66° and 79.34° respectively. A “magnitude” of immediate proximity by moving through either path towards the exit can be represented by calculating the value for the derivative of the function describing the absolute distance between one’s position in the maze and the coordinates of the exit:

$$\frac{\delta f}{\delta x} = \frac{x}{\sqrt{x^2 + y^2}}$$

Where $\frac{\delta f}{\delta x}$ is the magnitude of getting closer from the turning point to the exit by (1) going through the horizontal path in which case x denotes the horizontal distance to the exit, and y indicates the vertical distance to the exit, or by (2) taking the vertical path in which the roles of x and y are reversed within the formula. For the current default maze these values when continuing present action versus taking a turn were, $\frac{\delta f}{\delta x} = 0.98$ (horizontal path “utility”), and $\frac{\delta f}{\delta y} = 0.21$ (vertical path “utility”).

Besides (a) the “default maze”, we included three other mazes, which we will refer to as (b) the “extended maze”, (c) the “symmetric maze” and (d) the “turned maze” (see Table 1). The order of these mazes was varied following a Latin-square rotation and the navigation direction was manipulated between subjects. After completing the tasks, participants reported demographic information, were debriefed, and were thanked.

The extended maze. To plot the predictions based on the action continuation strategy against the initial segment, least angle, and immediate proximity strategies, we altered the default maze by extending its vertical segments between the turn points (2.3cm) and similarly shortening the horizontal segment (0.7cm), leading to different deviating angles, 51.06° and

38.94°, respectively, and modified distance derivatives, $\frac{\delta f}{\delta x} = 0.40$, and $\frac{\delta f}{\delta y} = 0.92$, respectively.

Based on the action continuation strategy, we still predicted the relative odds for choosing the upper over the lower path to be greater when navigating from west to east compared east to west, as for the default maze. However, by making the horizontal paths shorter than the vertical paths, the initial segment strategy makes the opposite prediction, as taking the *lower* path now yielded the longer initial segment when traversing from west to east as does the upper path when going from east to west. Similarly, the least angle strategy predicts preferences for the lower path when going from west to east given that the deviating angle of the vertical path was smaller than that of the horizontal alternative, and vice versa when going from east to west. Finally the immediate proximity account led to the opposite predicted pattern of preferences compared to the action continuation strategy.

The turned maze. Rather than having the entrance and exit on the west and east side, the turned maze differed from the default by including the entrance and exit at the top and bottom, which was done by rotating these parts by 90°, leaving the segments after the turn unaltered. The turned maze served two important purposes. First, an action continuation strategy would lead to the opposite prediction compared to the default maze: it was predicted that navigating from west to east should lead to a *reduced* likelihood to opt for the upper path versus lower path compared to when navigating from east to west. This follows from the fact that in this version of the maze, the lower path now required no initial turn when going from west to east and vice versa. Thus, based on the action continuation strategy a reversal of the pattern observed in Study 1 and 2 was anticipated.

Second, the turned maze provided an additional test against the alternative strategies. The initial segment account, for example, leads to a predicted preference for the upper path when traversing from west to east and a lower path preference when going from east to west, as each of the horizontal segments originating at the turn are longer relative to the

corresponding vertical segments. Also behavior based on the stay on the left proposition was different from the action continuation strategy, as was the case immediate proximity strategy, which would lead participants to take the first turn which yielded a higher distance derivative $\frac{\delta f}{\delta x} = 0.87$, relative to going straight, $\frac{\delta f}{\delta y} = 0.49$, resulting in relatively greater odds for choosing the upper over the lower path when navigating from west to east versus east to west. Further, the design allowed us to test the predictions based on the action continuation strategy also against the least angle strategy. According to the least angle strategy, navigators would be expected to have no clear preference for either one of the path because the angles were approximately the same (44.80° vs. 45.20°).

The symmetric maze. The last variation on the default maze consisted of relocating the entrance and exit at the middle of the upper and lower paths, hence requiring a turn regardless of which path was chosen. This alteration provided the opportunity to plot the action continuation strategy against the stay on the left account. Specifically, if taking a turn is an inevitable act regardless of which route is chosen—and both paths hence require a change—then the odds should not differ across navigation directions according to the action continuation strategy. According to the stay on the left account, however, the upper path should be chosen more frequently over the lower path when navigating from west to east compared to from east to west. In this maze variation, also the initial segments became equal (0.7cm), as did the deviating angles (90°), and the distance derivatives ($\frac{\delta f}{\delta y} = \frac{\delta f}{\delta x}$).

Results and Discussion

The default maze. A Chi-Square test indicated that choices for either the upper path versus the lower path were conditional on the direction through the maze, $\chi^2(1) = 7.24, p < .01, \phi = 0.28$ (Figure 2). Specifically, 68% of participants choose the upper path when going from west to east, compared to 40% when going from east to west. These results essentially replicate those of Study 1 and 2.

The extended maze. A Chi-Square test indicated that choices for either the upper path versus the lower path were again conditional on the direction through the maze, $\chi^2(1) = 5.16$, $p = .02$, $\phi = 0.23$ (Figure 2). A similar pattern was observed as for the default maze: 60% of participants choose the upper path when going from west to east relative to the 36% among those who went from east to west. These results support the predictions made based an action continuation strategy as well as the stay on the left account, but they are inconsistent with the predictions based on the initial segment, least angle, and immediate proximity strategy.

The turned maze. A Chi-Square test indicated that choices for the upper path versus the lower path were indeed dependent on the direction through the maze, $\chi^2(1) = 14.93$, $p < .001$, $\phi = 0.40$ (Figure 2). The opposite pattern was observed compared to the default maze: only 17% of participants choose the upper path when going from west to east,, as opposed to 55% among those who completed the maze from east to west were. This reversal is consistent with the predictions based on the action continuation strategy, but contradicts the predictions based on all other accounts.

The symmetric maze. As opposed to the prior mazes, a Chi-Square test indicated no reliable difference in the choices for the upper path over the lower path across the two directions, $\chi^2(1) = 1.11$, $p = .29$, $\phi = 0.11$ (Figure 2). Specifically, the percentage of participants choosing the upper over the lower path when navigating from west to east, 66%, did not significantly differ from the 55% who did so when going from east to west. These results contradict the predictions made based on the stay on the left account.

Across the above four mazes, the action continuation strategy was tested and plotted against the alternative initial segment strategy, the least angle strategy, the immediate proximity strategy, and a stay on the left account. Taken together, the results regarding the four mazes confirm the predictions based on the action continuation strategy. Moreover, the results of the maze variations were inconsistent with the predictions based on the other

accounts, lending overall support for an action continuation strategy in choosing between identical options in navigation tasks in a known environment, here in the context of drawn paths through mazes.

In relation to the least angle strategy in particular, it should be noted that the various maze variations yielded relatively low differences in deviation angles of paths. As a result, these studies may have somewhat underestimated the impact that the least angle strategy has in predicting choices. Moreover, the study employed drawn paths rather than more realistic navigation behavior in movement.

Study 4: Behavioral Replication and Direct Test of the Action Continuation Strategy

The previous study supports the action continuation strategy as process that informs decision making when faced with identical options. Study 4 was designed as a behavioral test of the action continuation strategy and it tested a crucial assumption of the action continuation strategy: the preferences as predicted would only occur after initial movement, that is, the particular action that is *continued*. Furniture was arranged to reflect the default maze. By adjusting people's starting positions in the maze we were able to manipulate whether or not choosing to go straight equaled a continuation of ongoing behavior. Specifically, by excluding behavior in the segment prior to the turn, we were able to remove earlier navigation behavior as the basis for the decision. We reasoned that if no initial action (i.e., movement) precedes the decision at the turning point (i.e., when no continuation is possible), then the navigation direction would no longer affect choices (Table 1; *e*).

Method

Forty-six people ($M_{\text{age}} = 23.37$, $SD = 9.36$; 24 women, 22 men) passing by on campus were asked for their voluntary participation in this field study. As opposed to completing each maze (Study 3), participants were assigned to either one of two maze variations (default maze vs. effortless maze) that were created using tables and chairs.

The default maze. The default maze measured approximately 5.5m by 2.50m, with open paths of approximately 50cm wide enclosed by furniture that was around 1m high. From the turn position, the horizontal and vertical segments measured approximately 1m and 3m, respectively (measured from the middle of the path), with deviating angles of 13.24° and 76.76° , respectively, and corresponding distance derivatives of $\frac{\delta f}{\delta x} = 0.97$ and $\frac{\delta f}{\delta y} = 0.23$.

In addition, we varied the navigation direction by asking people to first walk from west to east, and then from east to west. This was done by first positioning participants at the west side of the maze with a first experimenter, who instructed them to walk to a second experimenter located at the east side of the maze. At the east side, participants received a form on which they listed demographic information. They then returned this form back to first experimenter who gave a debriefing and thanked them for their participation. The chosen routes were recorded.

The effortless maze. We adjusted the default maze (see Table 1) by excluding the lead in movement before the turning point. Given that we took away the required effort for traversing some distance towards the choice location we labeled this the effortless maze. Specifically, participants walked through the maze without first completing the horizontal paths at the east and west entrances. As a result, choosing either the upper path or the lower path did no longer involve a deviation from prior navigation behavior. The initial segments' lengths remain unaltered by this procedure, and also the deviating angles and derivatives remained the same.

Results and Discussion

The default maze. A Chi-Square test on the disaggregated data indicated that choices for either the upper path versus the lower path were depended on the direction through the maze, $\chi^2(1) = 7.04$, $p < .01$, $\phi = .39$ (Figure 2). Consistent with the previous studies, 70% of

participants choose the upper path when going from west to east, versus 30% who did so when travelling from east to west.

The effortless maze. A Chi-Square test on the disaggregated data indicated that choices for either the upper path versus the lower path were not reliably affected by the navigation direction, $\chi^2(1) = 0.35, p = .55, \phi = 0.09$ (Figure 2). Specifically, the difference in the percentages of participants choosing the upper over the lower path when navigating from west to east, 61%, did not significantly differ among those going from east to west, 52%. These results are consistent with the prediction that no clear preference for one of the paths would emerge when the two decision options require a change in behavior.

General Discussion

In recent years an increasing amount of research addressed way-finding in the context of “identical options”, that is, decisions between paths that yield the same required investment to reach a common target. This novel interest is not surprising given that the asymmetric patterns of preference within such tasks shed light on basic problem solving strategies when people are faced with equivalent options. Whereas past research has suggested reliance on the initial segment and least angle strategies, we examined in four studies whether people rely on the action continuation strategy.

We tested the hypothesized action continuation strategy and contrasted it against the initial segment and least angle strategies as well as against predictions of a modified hill climbing approach labeled immediate proximity strategy. The first pair of studies revealed the asymmetric preferences documented in earlier research (Christenfeld, 1995) in the context of a paper-and-pencil maze (Study 1) as well as in the context of walking behavior (Study 2). In Study 3, the features of this maze were manipulated such that we were able to directly test the four abovementioned strategies against each other. The results were consistent with the action continuation strategy but not with the alternative accounts. For example, a shift in the angle of

the default maze's starting segment, leading to the turned maze, resulted in the reversal of preferences as predicted according to the action continuation account, but inconsistent with an initial segment approach, least angle strategy, or immediate proximity goal. Specifically, the switch did not affect the *length* of the initial segments originating at the point where participants were required to decide between paths but it did switch which path offered a continuation of the original direction. Similarly, the deviation angles of the two paths in this turned maze were approximately equivalent, leading the least angle strategy to predict similar preferences for either path. Results indicated, however, that the path offering a continuation of behavior was preferred, hence deviating from the equal preferences predicted by the least angle strategy, and these preferred paths also did start with the longest initial segment.

It should be noted, however, that the variations in the mazes used in Study 3 were perhaps too small to be completely confident in concluding that the action continuation strategy dominates over the least angle strategy. In addition, Study 3 utilized drawn mazes rather than more everyday life navigation behavior such as walking. Accordingly, we wish to express some caution about our manipulation of the least angle strategy as our test may not have been optimal.

Importantly, the behavioral examination in Study 4 indicated that the asymmetric preferences disappeared when the initial behavior was removed (i.e. people's first behavior was making a choice between paths rather than first travelling towards the choice location). In addition, this result was obtained without modifying any other properties of the maze (e.g., segment lengths, deviation angles), which suggests that this difference in behavior can indeed be attributed to the action continuation strategy in particular. Overall, these results support our proposition that people at least in part use action continuation strategies in way-finding behavior within known environments.

Contributions, Limitations, and Future Directions

The current research provides contributions to the study of cognitive processes at work when navigating in known environments. Consistent with earlier studies in decision making (e.g., Tversky & Kahneman, 1981), our findings reveal that choices from equally utile options, in the context of way-finding, are nonetheless asymmetrically valued. In navigating, people seem to use their current engagement to inform what to do when faced with decisions, favoring those alternatives that allow the continuation of their present traversing direction. This finding fits well into perspectives that emphasize the use of basic strategies in problem solving and decision making (e.g., Hastie & Dawes, 2010; Kahneman, Slovic, & Tversky, 1982; Plous, 1993).

The current research sheds light on how people make navigation decisions and how in particular an action continuation strategy underlies these choices. However, the present investigation also touches on issues that are more fundamental to the understanding behavioral navigation and movement, in particular the optimization functions that underlie planning and execution of behavior. An underlying assumption of each of the studied strategies is that there must be some utilitarian benefit inherent to the strategies. To illustrate, the wide use of heuristics such as availability (e.g., Tversky & Kahneman, 1973) stems from its relatively high efficiency in terms of time and effort relative to expenses in accuracy. Research into motor action planning (e.g., Trommershäuser, Landy, & Maloney, 2006) evidences striking convergence between expected utility models of motor tasks and actual human behavior (Trommershäuser, Maloney, & Landy, 2009). Indeed, behaviors such as eye and arm movements closely resemble theoretically predicted optimums in expected gains (e.g., high accuracy, small energy expenditure). Possibly, the action continuation strategy similarly optimizes a costs vs. benefits tradeoff. Consistent with this proposition, switching from an ongoing activity is generally costly in terms of accuracy and time (Allport et al.,

1994; Rogers & Monsell, 1995) and future research may identify the action continuation strategy as an expression of a more general cost-saving process in the context of way-finding behavior.

Originally, Christenfeld (1995) proposed that the asymmetric choices in navigation behavior may follow from the minimization of mental effort, a suggestion that was substantiated by Bailenson and colleagues (2000). It is plausible that such a process also underlies the action continuation strategy. Specifically, given the presumably high frequency with which people encounter navigation situations with multiple equivalent viable routes in daily life, a simple action continuation heuristic would reduce the frequent use of energy otherwise required when a separate thought-through decision would need to be made on each occasion. Speculatively, the energy saved by an action continuation strategy might even surpass small benefits in time and distance across paths when alternative routes are not identical in length. Examining the detailed biomechanical implications of the action continuation strategy went beyond the scope of the current investigation but yields an exciting future direction that may help uncover fundamentals in the economics of navigation.

In addition to the above, our research offers practical implications for real-world contexts. Navigation is a fundamental aspect of everyday life, highly relevant in contexts such as traffic, consumer behavior, and crowd management. In these settings, people are perhaps disinclined to divert from their current behavior, at least when the environment is known. This knowledge may be used to for example optimize traffic flow or to navigate people in a fast and safe way out of dangerous situations that may restrict the cognitive resources or time available for making deliberate decisions. For example, an implication from our research can be that when people are guided through traffic or large crowds, people may find their way easier, more efficiently, and perhaps also safer when an action continuation path was possible and recommended. The majority of people would “prefer” such a path; and if other people

moved from a different direction, using a different path that followed the action continuation principle, then the streams were least likely to collide. Similarly, in supporting healthy eating via placement of products in shops, it may pay off to present healthy products in isles located on the straight path from the entrance rather than the alternative. Future research will do well to examine whether the action continuation behavior indeed works in such settings, for example by comparing behavior across existing environments.

Interestingly, results for some of the tasks used in these studies revealed a general preference for lower path. Although we did not focus on this particular phenomenon, people may perhaps find it less effortful to draw lines the lower paths given that these require less extension of the arm, which would explain a somewhat general tendency to prefer the lower path. Importantly, the manipulation of navigation direction in these allowed us to test the action continuation strategy regardless of such general preferences. Nonetheless, this intriguing general preference may offer a future direction for identifying navigation processes complementary to the action continuation strategy.

Note that even though our results supported an action continuation strategy rather than the least angle strategy, the emergence of preferences for routes that involve the smallest deviating angle has been examined by Hochmair and Karlsson (2004) in settings that yield a key difference to the tasks investigated in the current research: These authors focused on *unknown* environments where people saw the target location, but were not knowledgeable of the exact layout of the routes that might get them there. Possibly, situations in which the exact layout of paths is unknown makes people engage in more effortful and thought trough decisions, hence reducing the reliance on a default action continuation. It would be worthwhile to examine in future studies the extent to which participants are able to verbalize the reasons behind their behavior and to see what part of their choice processes is available to consciousness. This future research should also examine the trade-off between action

continuation strategies and least angle strategies in which the difference between deviation angles are more extreme compared to those used in our study to examine whether the least angle strategy might become more prevalent with greater differences in deviation angles.

Extending on the above, the current studies were primarily developed to examine whether the action continuation strategy offers an explanations that better suits observed patterns in decision making relative to the other accounts. An alternative approach to be examined in future research would be to test whether people can use a mix of different strategies with each given a particular weight (e.g., Trommershäuser, Maloney, & Landy, 2008). Although such an examination goes beyond the scope of the current project that sought to identify the existence of an action continuation strategy, future research could examine the relative contributions of each of the strategies by changing the decision tasks in more ways than we did. For example, the use of strategies may shift towards the use of least angles with increasing uncertainty about the exact location of the goal.

In contrast to tasks such playing chess, the Tower of Hanoi puzzle, missionaries and cannibals problems, or the 8-coin dilemma (e.g., Newell & Simon, 1972; Ormerod, MacGregor, & Chrinocle, 2002; Robertson, 2001; Simon & Reed, 1976; Thomas, 1974), the navigation “problems” that were used in the current research were very easy to solve. Could our findings nonetheless be integrated with theories of problem solving in more complex contexts? Indeed, the importance of negative feedback on efficient problem solving progress is consistent with the general processes postulated in the classic TOTE model in problem solving (Miller et al., 1960) and theories of self-regulation (e.g., Carver & Scheier, 1998). Recent findings in problem solving evidence the importance of negative feedback (e.g., MacGregor, Ormerod, & Chronicle, 2001), for without negative feedback people may fail to alter ongoing behavior. Although many problem solving tasks and the currently examined navigation environment are very different in terms of complexity, our research highlights a

fundamental process that is potentially applicable to many other forms of problem solving and decision making.

Conclusion

Building on way-finding behavior research by Christenfeld (1995), we examined strategies that people employ when deciding between routes of equal length towards a goal in known environments. After contrasting various strategies against each other, including preferences for longest initial segments (e.g., Bailenson et al., 2000), preferences for movement in least deviating angles (e.g., Hochmair & Frank, 2002), and preferences for directions that temporarily increase one's direct proximity to the target, our results suggest that people often prefer to take the route that allows for the continuation of the original direction. Overall, it appears that when people face a choice between functionally equivalent routes, they partly modify their preferences in accordance with the option that allows them to just keep on going before changing one's route.

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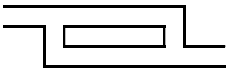
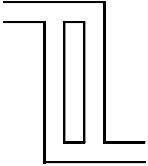
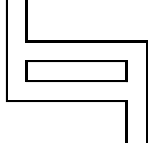
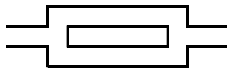
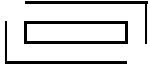
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Table 1

Predicted Decision for the Upper vs. Lower Path According to Each Strategy

										
	(a) Default		(b) Extended		(c) Turned		(d) Symmetric		(e) Effortless	
	W→E	W←E	W→E	W←E	W→E	W←E	W→E	W←E	W→E	W←E
Action Continuation	Upper	Lower	Upper	Lower	Lower	Upper	Equal	Equal	Equal	Equal
Initial Segment	Upper	Lower	Lower	Upper	Upper	Lower	Equal	Equal	Upper	Lower
Least Angle	Upper	Lower	Lower	Upper	Equal	Equal	Equal	Equal	Upper	Lower
Immediate Proximity	Upper	Lower	Lower	Upper	Upper	Lower	Equal	Equal	Upper	Lower

Note: Shaded cells indicate critical differences in predictions compared to the action continuation strategy.

Figure 1: The Embedded Identical Options Maze (Study 1)

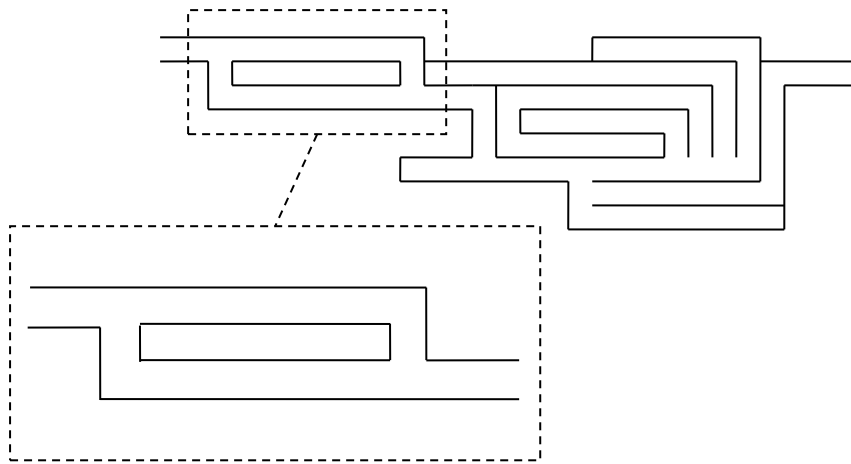
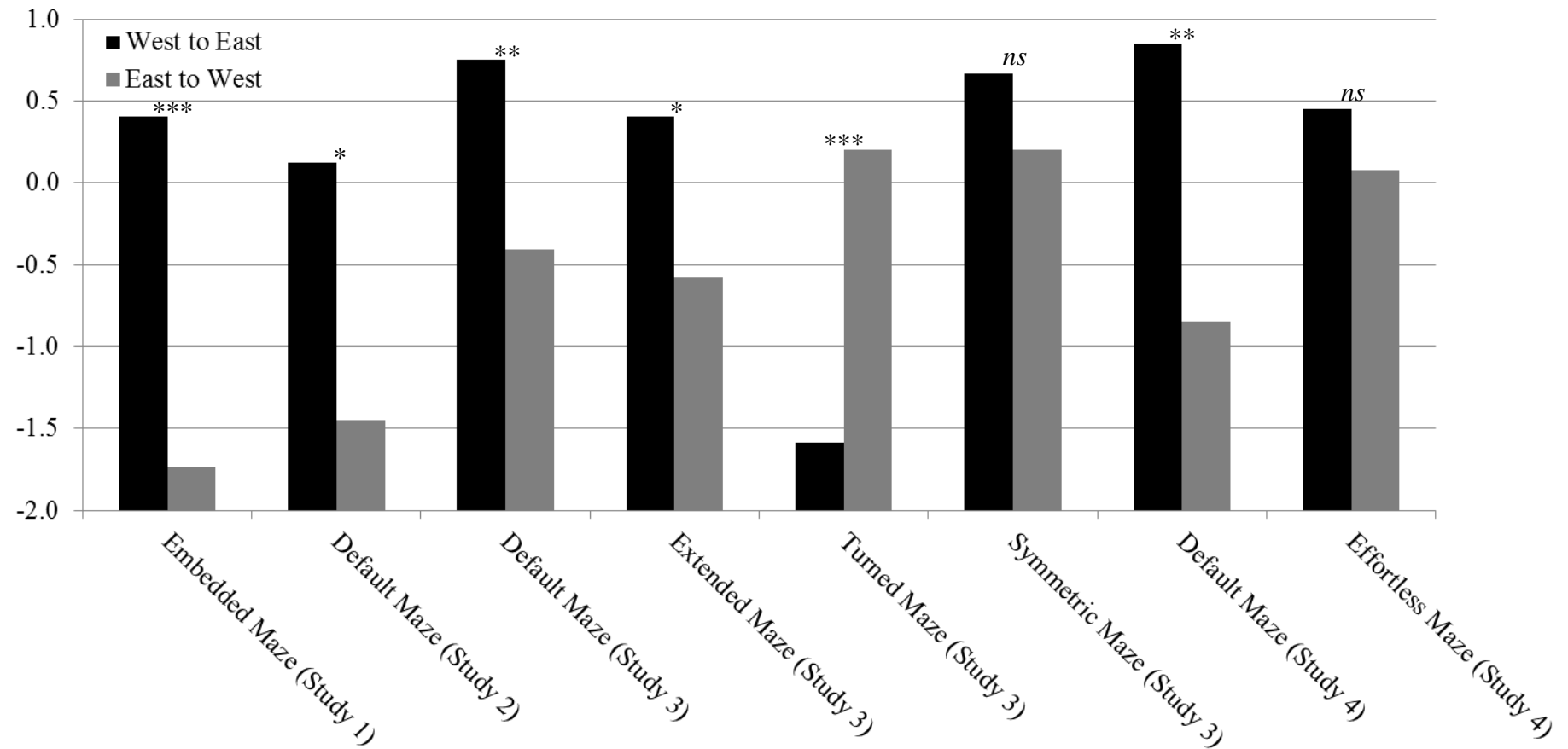


Figure 2: Ln(Odds) of Choosing Upper over Lower Paths Across all Studies



Note: An Ln(Odds) of 0 indicates equal preference for upper and lower paths. Positive values indicate a greater preference for the upper paths, whereas negative values indicate higher selection of the lower paths. * $p < .05$, ** $p < .01$, *** $p < .001$, ns $p > .05$.